The Relationship Between Strength Measures and Task Performance in Specialist Tactical Police

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ABSTRACT

Specialist Tactical Police Officers (STPO) carry heavier on-body loads than generalist police officers. Improvements in strength may mitigate the impacts of these heavier loads. The aim of this investigation was to determine the correlations between absolute and relative strength measures and occupational task performance in STPOs. Retrospective data were provided for 47 male specialist police officers from an elite Australian police unit. Data included body mass (mean = 89.0±8.58 kg), strength measures (1 Repetition Maximum [RM] measures for a bench press, squat, deadlift and pull-up) and task performance measures (85 kg victim drag wearing 15 kg of operational load and 5 km pack march wearing 40 kg of operational load). Pearson's correlations were conducted to determine relationships between measures and were plotted on a linear regressions model. Significant, moderate to strong correlations were found between all strength measures and victim drag performance and significant negative moderate correlations between relative bench press, absolute and relative squat and absolute and relative pull-up and pack march times. The absolute deadlift had the strongest correlation to the victim drag (r=0.747, p<0.01) while the relative pull-up showed the strongest correlation with pack march performance (r=-0.466, p<0.01). The requirement to lift a portion of the dummy off the ground during the victim drag may explain the increased importance of absolute strength while the requirement to transport load affixed to the body may explain the importance of relative strength requirements. Improvements in absolute and relative upper and lower body strength may improve task performance in this population.

Keywords**:** SWAT, Tactical Personnel, law enforcement, elite, load carriage

INTRODUCTION

Police officers must be prepared to perform physically demanding and arduous occupational tasks that require them to run, jump, crawl, climb or push/pull with maximal exertion (3, 22, 24). Furthermore, they may be required to perform these tasks while apprehending an uncooperative suspect (28, 29) and whilst carrying occupational loads (1). On average, these occupational loads can weight around 10 kg (1) and have been known to reduce officer power, agility, and change of direction speed (13, 19).

Policing situations which are deemed extreme in nature are handled by specialist tactical police officers such as those serving in Special Weapons and Tactics (SWAT) units (6). These specialist tactical units of the police forces consist of specialist tactical police officers (STPO) who are trained and employed to resolve critical incidents involving a threat to public safety (6). The critical nature of the tasks carried out by STPOs require them to carry threat-dependent weaponry, body armor, and equipment (such as breaching devices, gas masks, etc.) (6). This equipment can add an additional 10 to 30 kg of load to their bodies above that of general police officers (1, 5, 14). With these necessary additions to the STPOs operational load, there is typically a concurrent detrimental effect on their ability to complete occupational tasks (5) and an increased physiological burden (2, 4). This increased physiological burden highlights the importance of developing and maintaining optimal physical fitness in STPO (7, 8, 23).

The requirement for STPO to be physically strong is noted in the literature, as is the fact that these officers are typically stronger than the general population (17). For example, previous research by Robinson et al. (25) found that both absolute and relative strength measures were associated with STPO load carriage performance over repeated 5km load carriage events completed as fast as possible (pack weight of 25 kg). Significant weak to strong correlations were found between strength measures of 1 Repetition Maximum (1RM) deadlift (absolute r=-

0.288; relative r=-0.403), bench press (absolute r=-0.360: relative r=-0.465), squat (absolute r=0.452: relative r=-0.500), and pull-up (absolute r=0.452: relative r=0.607) for the first march with the later three measures significantly correlated with the subsequent second and third pack marches (each approximately 4 months apart). Of note however, across all four of these strength measures, the relative strength values were more strongly correlated to the load carriage task than the absolute values. Conversely, recent work by Moreno et al. (18) found that absolute deadlift measures were more strongly correlated to a 75 and 91 kg dummy drag than relative measures, with the latter not being significantly related. These findings suggest that while strength measures are important to the performance of tasks that can typically be undertaken by STPO, the nature of the strength, be it absolute or relative, may change depending on the task.

By understanding the different strength needs of STPO (in terms of relative or absolute strength) informed conditioning practices can be put in place to better optimize officer performance, especially in tasks where they may be weaker (e.g. load carriage versus a victim drag). The aim of this study was to investigate the relationship between measures of strength (absolute and relative) and task performance (85 kg victim drag and 5 km pack march) in STPO. It was hypothesized that strength would be related to performance on both tasks and that the nature of strength required (absolute and relative) would differ between tasks.

METHODS

Experimental Approach to the Problem

Retrospective data were provided from an elite Australian specialist police unit. Body mass data were provided in addition to data collected for strength performance (1RM bench press, 1RM squat, 1RM deadlift, 1RM pull-up) as part of departmental process. Relative strength data

were derived by dividing 1RM scores by each individual's body mass. Furthermore, results from two performance measures (85kg Victim Drag [15 kg officer load] and a 5km loaded [40 kg officer load] Pack March) were also obtained as part of departmental processes.

Subjects

Data were obtained in non-identifiable format pertaining to 47 male STPOs from an Australian law enforcement agency. The strict security protocols regarding the protective identity of these individuals limited all identifiable information to only body mass (mean = 89.0 ± 8.58kg) and the resulting performance. The limitation of demographic data in this population has been reported in previous literature (21). Ethics approval for this study were provided by the Bond University Human Research Ethics Committee (RO1585) and clearance to publish this information provided by the relevant law enforcement gatekeeper approvals.

Procedures

Strength measures were collected over two days (Day 1 – bench press and deadlift: Day 2 – squat and pull-up) with the victim drag and pack march assessments conducted in the following week on independent days. Details regarding the protocols for the strength and performance measures are detailed below and has been previously described in the literature (25).

Strength Measures: The intent of a 1RM test is to determine the single maximal voluntary effort force that a muscle or muscle group can exert (11), and was utilized given its consideration as the gold standard for non-laboratory based strength assessments (10). The 1RM testing protocols were conducted as previously described by Haff and Triplett (11) and were always preceded by a 10-minute warm up on each day of testing. The warm up consisted of self-selected exercises such as Hindu pushups with rotation, bodyweight squats, clock lunges, supine gluteal bridges, 5-10kg medicine ball slams, push-ups and alternating lunges.

The Bench Press

Subjects completed the bench press testing using a 20kg Pendlay Barbell loaded with Gym branded bumper weight plates, utilizing a Hammer Strength Bench rack (LifeFitness, Rosemont, IL) and a Strength and Conditioning (S&C) coach for safety. Subjects were instructed to lay supine on the bench with both feet flat on the floor with gluteals and scapulae in contact with the bench. Grip width was slightly wider than shoulder width (at a comfortable position) to ensure 90° of elbow flexion was achieved at the end of the eccentric phase of the lift. The test initiated with the officer un-racking the weight and holding it with arms fully extended at the midline of their sternum. The barbell was lowered at a controlled speed until contact was made with the chest, and thereafter returned to the starting position above the sternum. A lift was only considered successful if the gluteals and scapulae remained in contact with the bench throughout the movement and the participant did not require any assistance from the spotter. The final load (including bar weight) lifted correctly was measured in kg to form the final score.

The Squat

The back squat utilized a 20kg Pendlay Barbell, Gym branded bumper weight plates in a Hammer Strength Bench rack (LifeFitness, Rosemont, IL) with two S&C coaches as spotters. The subjects were instructed to position themselves so that the barbell was in contact with upper fibers of the trapezius, above the scapulae. Foot and grip placements were instructed to be slightly wider than the shoulders at a comfortable position. The test began with the officer removing the barbell from the rack and taking two steps back to a pause. The participant was instructed to perform the squat to 90° of knee flexion before extending to full hip and knee extension. The final load (including bar weight) lifted correctly was measured in kg to form the final score.

120 **The Deadlift**

121 The deadlift protocol was completed use an a 24kg diamond-shaped barbell (Australian Barbell
122 Company, Mordialloc, VIC) loaded with Gym branded bumper weight plates (LifeFitness,
123 Rosemont, IL). A rubber matted area of the gym was utilized for the testing. The subjects were
124 positioned inside the diamond shaped barbell and instructed to place their feet shoulder width
125 apart. The officers were instructed to squat, grip the barbell and maintain a neutral neck position
126 with feet flat on the ground. The test began with a cue followed by hip and knee extension in a
127 controlled manner. Once full hip and knee extension was achieved a second cue was provided
128 to lower the weight. Displays of poor lifting technique were met with cessation of the lift and
129 an unsuccessful lift result. The final load (including bar weight) lifted correctly was measured
130 in kg to form the final score.

131 **The 1 RM Pull-Up**

132 Subjects completed the pull-up assessment with a Dan Baker Strength weight belt
133 (DanBakerStrength Sunshine Coast, QLD, Australia), and Gym branded bumper plates
134 attached to hang in front of the body. The officers were instructed to grip the bar wider than
135 shoulder width at a comfortable position ensuring 90° of elbow flexion at the end of the
136 concentric phase. The subjects were instructed to maintain a knee flexion at ~90° with ankles
137 crossed behind them during the movement. The test began on the with a cue to initiate the
138 concentric phase. A repetition was deemed successful if there was no swinging of the legs
139 during the movement and the chin was raised above parallel with the bar with 90° of elbow
140 flexion. 1RM values achieved were the result of adding the officer's body mass to the external
141 weight lifted.

142 **Victim Drag protocol**

The victim drag was completed using an 85kg Life Tec dummy placed with its head on the starting line facing the direction of pull. A 50m long course was set up using Hart Sport cones (Hart Sports, Brisbane, Australia) placed every 5m on a flat concrete surface. Subjects were required to wear their tactical uniform, standard issue boots, body armour and helmet totalling approximately 15kgs (loads varied slightly due to natural variations in individual clothing and footwear sizes and subsequent ballistic plate sizes). The subjects were instructed to grip the dummy under the arms and drag it backwards as fast and far as possible in the time allowed. Each participant had 10 sec to drag the dummy as far as possible before receiving a 20 sec rest where they could drop the dummy. This process was repeated 6 times, totalling 60 sec of work with 120 sec of rest. The distance was scored by the number of markers passed by the feet of the dummy by the end of the 6^{th} interval.

Pack March protocol

The 5km pack march was completed over a course marked out on a combination of bitumen and hard dirt surfaces. The subjects were required to wear their issued operational uniform, boots, and body armour, alongside an unloaded primary weapon. On-body loads totalled 15 kgs which was measured with a Tanita BC82Fitplus scale (Tanita, Illinois, USA). In addition, subjects wore an operational backpack which weighed 25 kgs (Wedderburn Ds530 Digital Industrial scale), leading to a total load of 40 kg. The officers completed the 5 km march at their own pace as fast as possible and time to completion was measured with a Hart Sports hand held timer (Hart Sports, Brisbane, Australia). The final result was recorded in minutes and seconds.

Statistical Analyses

Data were received in a non-identifiable format on Microsoft Excel spreadsheets and subsequently imported into a Statistical Package for the Social Sciences spreadsheet (Version

23) for statistical analysis. A descriptive analysis to determine means and standard deviations for body mass, independent variables (absolute and relative strength measures) and dependent variables (Victim Drag and Pack March performance) was performed. A priori power analysis was conducted using G*Power software (Version 3.1.9.2, 2014) indicating a large effect size (p=.5, alpha=0.05) could be detected with a 95% confidence interval for the Pearson's correlations given the population size. Pearson's correlations were performed on each measure of strength (both absolute and relative) and both performance measures (Victim Drag and Pack March). The strength of the correlations were defined as an r of between 0 to 0.19 as very weak; 0.2 to 0.39 as weak, 40-.59 as moderate, 60-.79 as strong and .80-1.0 as very strong (9). Correlations were plotted on a backward linear regressions model and analyzed for variance (r2) between strength measures and occupational tasks. Alpha levels were set a 0.05 a priori.

RESULTS

The absolute and calculated relative results for each strength measure and the results of both occupational tasks can be seen in Table 1. Table 2 shows the correlations between each strength measure and task performance. For the victim drag task, all absolute strength measures displayed significant ($p<.01$) and strong correlations with drag performance while the relative results showed significant ($p<.01$) moderate correlations (Table 2). Of all strength measures, the absolute deadlift accounted for 56% of the variance in victim drag (Figure 1). For the pack march task, the relative strength measures for the bench press, squat, and pull-up displayed significant ($p<.05$) weak to moderate ($p<0.01$) correlations with the pack march results, while only the absolute squat and pull-up showed significantly ($p<.05$) weak correlations with pack march performance. Of all the strength measures, the relative pull-up accounted for 22% of the variance in the pack march (Figure 2).

Insert table 1 here

Insert table 2 here

*** Figures 2 and 3 here***

DISCUSSION

The aim of this study was to investigate relationships between measures of strength and task performance in STPO. The results suggest that both absolute and relative strength are strongly correlated with victim drag results and absolute and relative squat and pull-up strength are moderately correlated with pack march results. Strength, both absolute and relative, appears to be important for STPO task performance. On this basis, the development and maintenance of these strength measures are an occupational requirement for STPO. Furthermore, these measures are of importance in return-to-work rehabilitation and reconditioning processes following injury.

The interpretation of these results suggest that, while relative strength was correlated with victim drag performance, absolute strength may be of greater importance. The findings of this study partially support the findings of Moreno et al (18). While Moreno et al. (18) (n=30 students) found no significant relationships between relative deadlift performance and a victim drag (75 & 91 kg drag). they did find strong significant correlations between absolute deadlift performance and a victim drag. Likewise, in a study measuring only absolute strength measures, Hendrickson et al. (12) found significant correlations between improvements in 1RM bench press (r=0.32) and squat (r=0.33) (the only strength values measured) and victim drag (61.4kg) performance in a group of recreationally active civilian women (n=56), One potential reason why absolute strength may be of greater importance in a victim drag, as opposed to relative strength, lies in the requirement of the participant to lift a portion of the dummy off the ground and drag this absolute load, which is not affixed to their body and remains extant regardless of the participant's body mass.

Conversely, a pack march requires the participant to move a worn load as part of their body mass, hence this becomes a relative load. Although this is known to increase energy costs (15), this may also mean that the relative strength of the carrier may be of greater importance. This supposition is supported by the findings in this study, whereby relative strength measures were more strongly correlated to pack march performance than absolute measures. In addition, the results of this study support the findings by Robinson et al. (25) who likewise found relative measures to be more strongly correlated to a pack march event than absolute measures.

In this study absolute pull-ups and squats were significantly, albeit weakly correlated to pack march performance while absolute bench press and deadlift were not. Conversely Robinson et al., (25) found all measures of an absolute bench press, squat, pull-ups and deadlift were moderately to weakly correlated to one pack march event; however, the deadlift was no longer significantly correlated to two later pack marches. Similarly, the study by Hendrickson et. al. (12) found no significant correlation between pack march performance (3.2k m with 32.7 kg) and improvements in absolute bench press or squat.

The different findings to that of our own study, with respects to a loaded pack march performance, may be due to the different populations studied. There is an underlying cardiovascular demand for performance in a loaded pack march (12, 27) which would be expected to be present in tactical personnel who have been exposed to pack marching previously (26). The previous study used civilians who were instructed on how to perform these tasks, and therefore would likely have had little familiarity with conducting them.

The results of this study support research investigating optimal conditioning measures for pack marching. Systematic reviews by Orr, et al. (20) and Knapik, et al. (16) highlighted that pack marching can be improved by a combined resistance training and an aerobic training program. However, the results of this finding suggest that while resistance training and the development

of strength is advised to improve load carriage performance, the development of relative strength may provide of greater value for pack marching specifically.

A notable limitation to this study is the measures of strength and the occupational tasks selected. These measures and tasks were those in use by the law enforcement agency and, as the data provided were retrospective, were beyond the control of the researchers. However, given that these measures are in use, this research informs those not only in this agency, but other agencies who employ these assessments and tasks, on best means of optimizing performance.

With the growing number of STPO units internationally, a greater need for research into training methods and optimizing performance has become increasingly evident (7, 29). The results of this study highlight the relationships between upper and lower limb strength (both absolute and relative) and the performance of two key tasks performed by STPO.

PRACTICAL APPLICATIONS

Strength and conditioning programs for candidates wishing to serve in, currently serving officers of, or injured officers returning to, specialist tactical police units should include the development of both absolute and relative strength, utilizing maximum strength training methods and movements for the upper and lower body as part of their strength / reconditioning program. Furthermore, if increased performance in a victim drag is desired increases in absolute strength may be of greater benefit given that the dummy represents an absolute load of which a portion must be lifted from the ground and dragged. Conversely, during a pack

262 march, where the load is affixed to the body and must be transported by the carrier, increases
263 in relative strength to body mass ratio may be of greater benefit.

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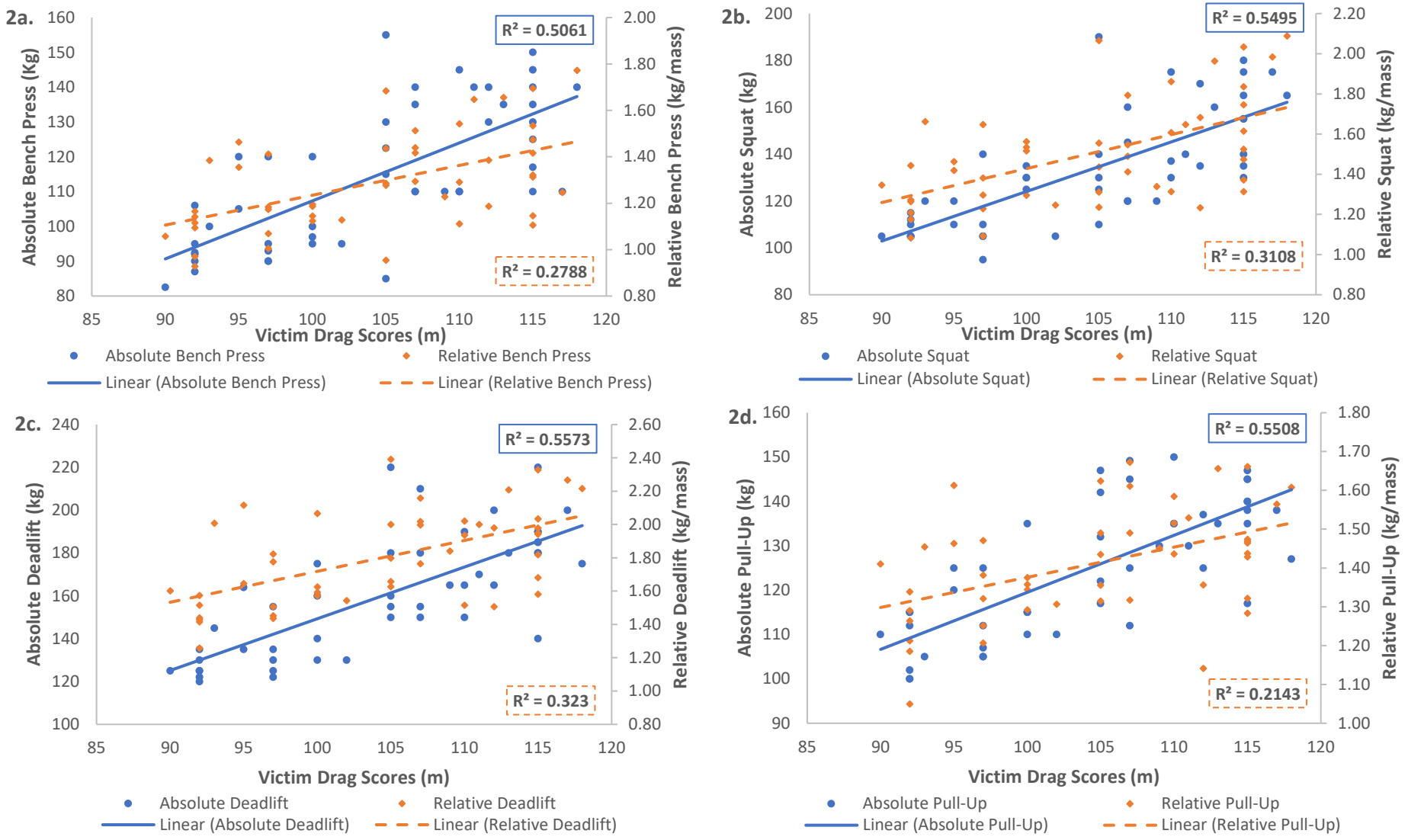

Figure 1. Linear regression analyses for absolute and relative strength measures and victim drag performance. **2a.** Absolute/relative bench press correlation to victim drag performance, **2b.** Absolute/relative squat correlation to victim drag performance, **2c.** Absolute/relative deadlift correlation to victim drag performance, **2d.** Absolute/relative pull-up correlation to victim drag performance.

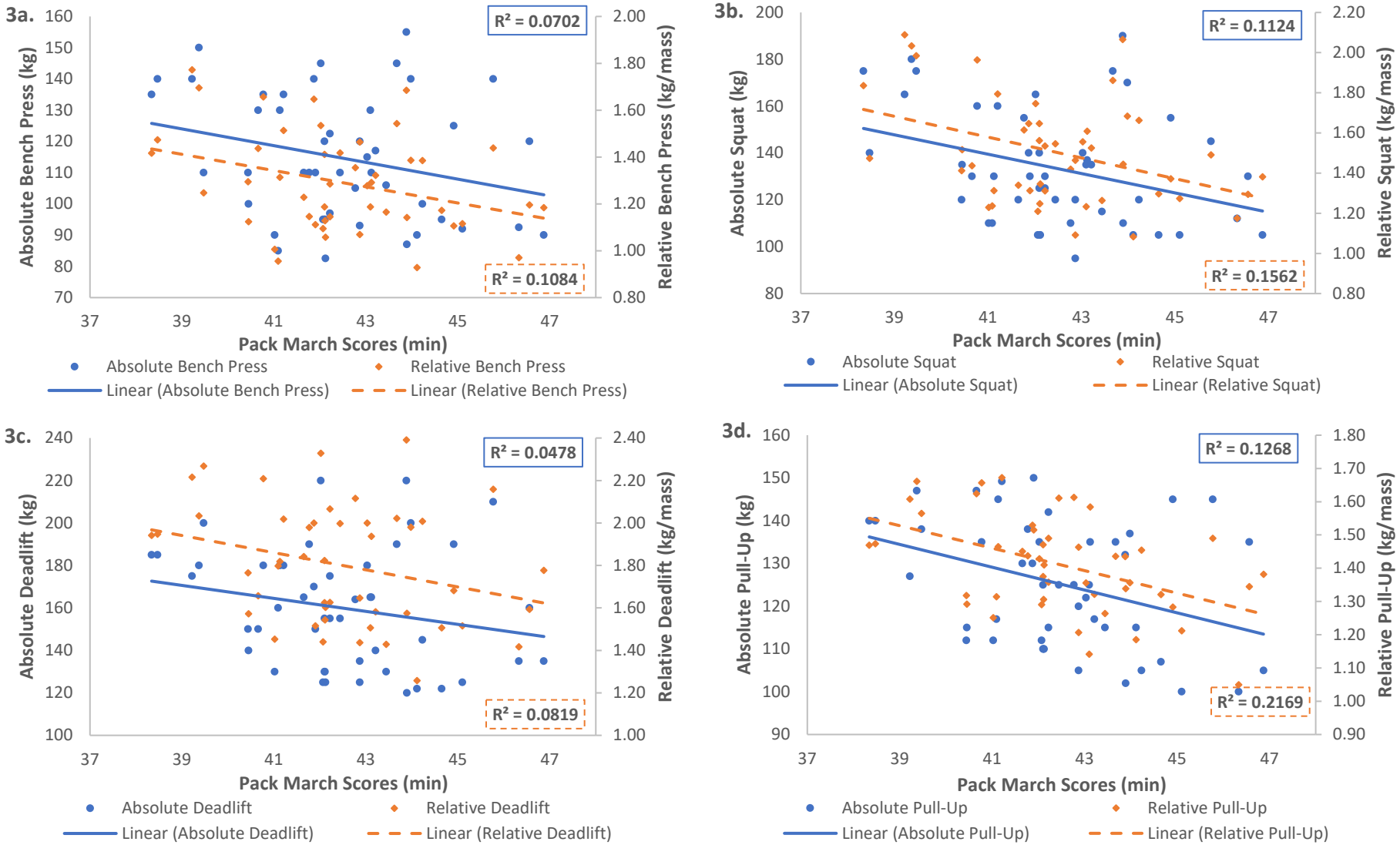

Figure 2. Linear regression analyses for absolute and relative strength measures and pack march performance. **3a.** Absolute/relative bench press correlation to pack march performance, **3b.** Absolute/relative squat correlation to pack march performance, **3c.** Absolute/relative deadlift correlation to pack march performance, **3d.** Absolute/relative pull-pp correlation to pack march performance.

TABLES

Table 1. Mean results from all outcome measures and demographic data supplied.

Outcome Measure	Mean results ± SD
Body mass (kg)	89.00 ± 8.58
Absolute Bench (kg)	114.68 ± 20.15
Relative Bench	1.29 ± 0.21
Absolute Squat (kg)	133.38 ± 24.58
Relative Squat	1.50 ± 0.26
Absolute Deadlift (kg)	159.96 ± 27.88
Relative Deadlift	1.80 ± 0.28
Absolute Pull-up (kg)	125.17 ± 14.93
Relative Pull-up	1.41 ± 0.14
Victim Drag (m)	104.40 ± 8.61
Pack March (mins)	42.48 ± 1.99

Relative measures presented as ratio of strength to body mass (1RM/Body mass).

Table 2. Correlation between outcome measures and performance in the victim drag and pack march performance tests.

Outcome Measure	Victim Drag	Pack March
Absolute Bench	$r = 0.711^{**}$	$r = -0.265$
Relative Bench	$r = 0.531^{**}$	$r = -0.330^{*}$
Absolute Squat	$r = 0.741^{**}$	$r = -0.335^{*}$
Relative Squat	$r = 0.557^{**}$	$r = -0.395^{**}$
Absolute Deadlift	$r = 0.747^{**}$	$r = -0.219$
Relative Deadlift	$r = 0.568^{**}$	$r = -0.285$
Absolute Pull-up	$r = 0.742^{**}$	$r = -0.356^{*}$
Relative Pull-up	$r = 0.465^{**}$	$r = -0.468^{**}$

Statistically significant at: *p <0.05; **p <0.01.

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